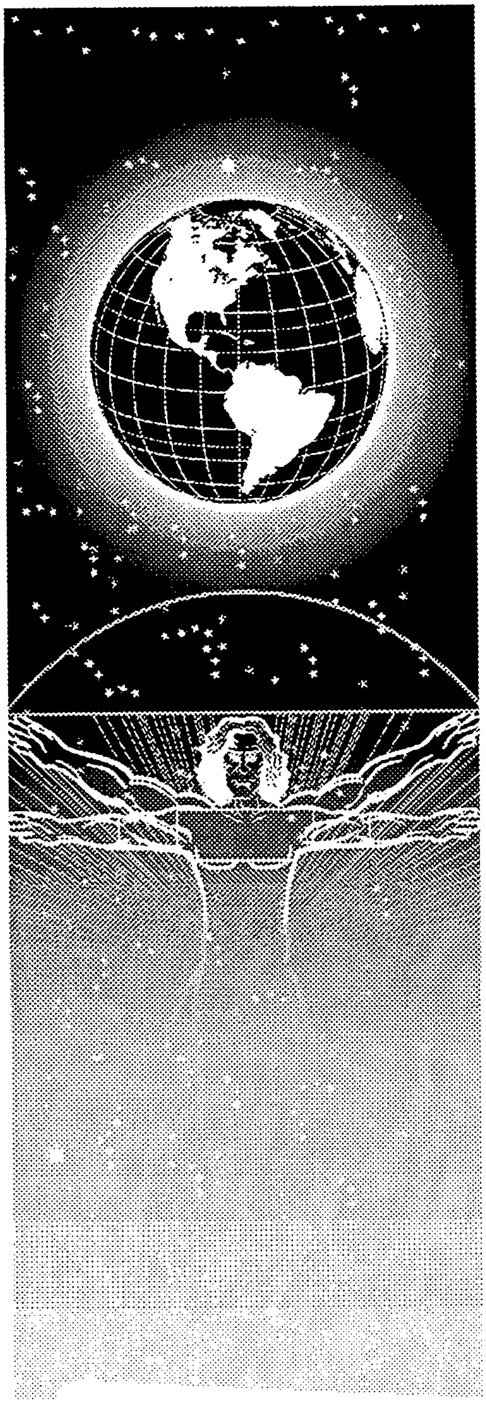
AL/HR-TP-1997-0046



UNITED STATES AIR FORCE ARMSTRONG LABORATORY

CONTINGENCY OPERATIONS LOGISTICS REQUIREMENTS (COLOR) PROGRAM

John P. Schroeder, 1Lt, USAF

HUMAN RESOURCES DIRECTORATE
Logistics Research Division
2698 G Street
Wright-Patterson Air Force Base, Ohio 45433 7604

James Bumgarner

Computer Sciences Corporation
3000 Presidential Drive, Suite 100
Fairborn, Ohio 45324

September 1997

Approved for public release; distribution is unlimited.

AIR FORCE MATERIEL COMMAND
ARMSTRONG LABORATORY
HUMAN RESOURCES DIRECTORATE
7909 Lindbergh Drive
Brooks Air Force Base, TX 78235-5352

NOTICES

JOHN P. SCHROEDER, 1Lt, USAF
Research Scientist

BERTRAM W. CREAM, Chief
Logistics Research Division

REPORT DOCUMENTATION PAGE			*Form Approved* *OMB No. 0704-0188*

1. AGENCY USE ONLY *(Leave blank)*	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	September 1997	Final -Mar 94 to Mar 97

4. TITLE AND SUBTITLE Contingency Operations Logistics Requirements (COLOR) Program	5. FUNDING NUMBERS C - F33657-92-D-2055 PE - 63106F PR - 2940 TA - 03 WU - 10
6. AUTHOR(S) John P. Schroeder, 1Lt, USAF James Bumgarner	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Computer Sciences Corporation 3000 Presidential Drive, Suite 100 Fairborn, Ohio 45324	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) Armstrong Laboratory Logistics Research Division 2698 G Street Wright-Patterson AFB OH 45433 7604	10. SPONSORING/MONITORING AGENCY REPORT NUMBER AL/HR-TP-1997-0046
11. SUPPLEMENTARY NOTES Armstrong Laboratory Monitor: 1Lt John P. Schroeder, AL/HRGA, DSN 785-9945	
12a. DISTRIBUTION AVAILABILITY STATEMENT Approved for public release; distribution is unlimited	12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

All work performed by the Computer Sciences Corporation in support of Armstrong Laboratory's COLOR program is described in this document. Three reports, a database, and updates to this database were previously delivered covering six distinct tasks. The first deliverable was a support equipment database and corresponding documentation. The second highlighted Air Force acquisition policies and procedures. The third task was a preparation of a Payoff Assessment Analysis Study. Next, CSC identified the functional support needed for maintaining and servicing the F-16C/D weapon system. Additional aircraft were investigated and reported in updates to the database documentation. A final report documented actual on-aircraft electrical power consumption measurements for numerous aircraft.

14. SUBJECT TERMS			15. NUMBER OF PAGES
aerospace ground equipment	database	support equipment	23
acquisition model	maintenance task		16. PRICE CODE
electrical power	performance requirements		

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	SAR

CONTENTS

PREFACE

This effort was jointly accomplished by the USAF Armstrong Laboratory, Logistics Research Division (AL/HRG), Wright-Patterson AFB, Ohio and Computer Sciences Corporation (CSC) Professional Services Group, Fairborn, Ohio. The work was performed under Workunit 2940-03-10. The principal authors for this effort were Lt. John Schroeder from Armstrong Laboratory and Mr. Jim Bumgarner from CSC.

This report summarizes the various reports and analyses that CSC accomplished for Armstrong Laboratory during the period of March 1994 to March 1997. The report is not intended to provide specific detail of each task, but rather assist researchers in determining what subject areas warrant more attention and which reports contain that detailed information. It also provides a timeline of events and results, and an illustration of possible benefits and shortfalls. Detailed reports do exist for many of these efforts and anyone interested should contact Armstrong Laboratory for further information.

The authors wish to acknowledge two individuals for their assistance in the completion of this report. Mr. Matt Tracy of Armstrong Laboratory was especially helpful in providing content and editing suggestions. Mr. Marty Wert of CSC assisted by providing technical expertise on flightline operations.

LIST OF ABBREVIATIONS

AGE	Aerospace Ground Equipment
AFB	Air Force Base
AFLC	Air Force Logistics Command
AL/HRG	Armstrong Laboratory, Logistics Research Division
COLOR	Contingency Operations Logistics Requirements
CSC/PSG	Computer Sciences Corporation, Professional Services Group
KVA	Kilo-Volt Ampere
MASS	Modular Aircraft Support System
NSN	National Stock Number
PAA	Payoff Assessment Analysis
PID	Prime Item Development
PPM	Pounds Per Minute
SE	Support Equipment
SEE/IT	Support Equipment Evaluation/Improvement Techniques
SERD	Support Equipment Recommendation Data
SPO	System Program Office
SS/EDA	System Support, Early Depot Activation
TO	Technical Order
TM	Trade Mark
USAF	United States Air Force
UTC	Unit Type Code
VA	Volt-Ampere

SUMMARY

This report is a summary of all work performed by Computer Sciences Corporation in support of the Armstrong Laboratory, Logistics Research Division (AL/HRG) Contingency Operations Logistics Requirements (COLOR) Program. Work began in March 1994 and continued through March 1997. Three reports, a database, and updates to this database were delivered to Armstrong Laboratory covering six distinct task efforts.

Computer Sciences Corporation Professional Services Group (CSC/PSG) began the first task in support of the COLOR Program in March 1994. The first task was the collection of data on aircraft support equipment (SE) and the design of a SE database to store this information. This database provided a single repository of SE data required for support equipment research and development programs. It became known as the COLOR database and the first edition, which included a listing of 326 SE items, was delivered to AL/HRG on 24 June 1994.

In the Fall of 1994, Air Force acquisition policies and procedures underwent complete review and reorganization. The second task for CSC was to research current and planned Air Force methods for the acquisition of support equipment. The results from this four month research study were documented in an Acquisition Model that was delivered to AL/HRG on 24 October 1994.

CSC's third task was the preparation of a Payoff Assessment Analysis Study and report. The purpose of this effort was to review SE acquisition and operational problems and identify areas where AL/HRG and the Air Force could best concentrate their research effort. Because of the recent Gulf War activities in the Middle East, much emphasis was placed on problems identified there, especially reducing the deployment footprint of SE required to support deployed forces. Most deployable SE is in the form of Aerospace Ground Equipment (AGE) and its associated spares, technical orders, and tools. The Payoff Assessment Analysis Report identifies potential AGE research and was delivered to Armstrong Laboratory on 13 December 1994.

In order to better understand the functional support needed to maintain and service aircraft, a fourth task was undertaken. CSC identified periodic maintenance tasks for the F-16C/D weapon system, as well as the most frequent maintenance actions required due to aircraft failures. An Aircraft Performance Requirements Database Listing consisting of 140 records for selected F-16 maintenance and servicing tasks was delivered to AL/HRG on 31 May 1995.

In June 1995, AL/HRG contracted separately with Battelle Memorial Institute to determine actual aircraft performance requirements for various weapons systems. As task five, CSC began doing similar research on additional aircraft. The results of this research were somewhat limited by time and access to selected organizations, but the data collected was incorporated into an Aircraft Performance Requirements Database Table. This table was documented in the Updated COLOR Database, delivered to Armstrong Laboratory on 30 November 1995.

The final task performed by CSC was an extension of the determination of the actual aircraft performance requirements on selected aircraft. It was decided that actual on-aircraft electrical power consumption measurements were the most desirable method of obtaining the external ground electrical power required. A Dranetz 4300 Power Platform was leased from April through November 1996 to measure and record electrical power consumed during ground maintenance tasks. Electrical measurements were performed more than 50 times on ten designated aircraft types. Results of these measurements were added to the Aircraft Performance Requirements Database and documented in the Aircraft Electrical Measurements Test Report dated 28 February 1997.

INTRODUCTION

The Armstrong Laboratory Logistics Research Division performs research and development focused on technology that improves the performance of integrated systems of people, information, and equipment for performing essential acquisition and logistics support functions in peacetime and war. In 1994, AL/HRG began exploring the support equipment realm in an effort to improve reliability, maintainability, and deployability of SE assigned to deployable units. With the exception of automated test equipment, the support equipment field had been a fairly neglected Integrated Logistics Support element in the areas of modernization and research. Initial research uncovered many Air Force initiatives to reduce the logistics footprint. For example, weapon systems were being encouraged to find ways to trim weight and volume from mobility packages and were now assessed by a new metric: deployability (Boyle, 1995).

The Composite Wing Future Requirements Study by Northrop identified several new technologies for support equipment that had the potential to reduce the airlift needed for deployment of a composite wing (Northrop, 1993). Many of these technologies focused on aerospace ground equipment. An analysis of all available information led AL/HRG to focus its future research on those pieces of AGE that might be incorporated into a Modular Aircraft Support System (MASS) conceptual design. This concept consisted of carts that supplied electricity, cooling air, nitrogen, hydraulic fluid, and related utilities required to support aircraft ground maintenance and servicing tasks.

In March 1994, AL/HRG contracted with Computer Sciences Corporation Professional Services Group to define support equipment issues, and to highlight future AL/HRG research and development efforts that could provide cost-effective solutions for support equipment requirements and problems. CSC's effort supported of Armstrong Laboratory's Contingency Operations Logistics Requirements (COLOR) project. The goal of COLOR was to gather and analyze data related to SE in support of in-house and contracted research. Initial support equipment research highlighted a significant lack of documented problems and integrated data sources for SE. COLOR helped eliminate this basic research problem by providing a single source for the data required to perform support equipment research and development.

This report summarizes the work performed by CSC. Each section describes a logical tasking of the work as well as the product. These are only summaries; additional data on each product can be received by contacting AL/HRG or the Defense Technology Information Center (DTIC) for the reports.

SUPPORT EQUIPMENT DATABASE

Background

The initial CSC contract covered the period March through December 1994. For this nine-month undertaking, CSC's effort focused on three areas: design, develop, and populate a support equipment characteristics and parameters database; research and document a support equipment acquisition process model; and conduct a Payoff Assessment Analysis to identify areas where future AL/HRG research might provide the greatest benefit.

The Support Equipment Database was the first deliverable document. The objective was to build a database to store and retrieve information collected on selected Aerospace Ground Equipment or SE items. Microsoft FoxPro Relational Database Management System for Windows™, Version 2.5, was selected as the database system. Besides being one of the fastest databases available for personal computers, FoxPro was available at the Armstrong Laboratory customer site, and CSC had programmers familiar with the software.

Approach

Initially, selected data elements were identified, and data on specific SE items were collected and organized using Microsoft Excel commercial software. This data was then entered into the FoxPro SE Database as the SE Database was developed. Data elements and definitions used for the SE Database are included in the initial Support Equipment Database Report dated 24 June 1994 and were updated in subsequent deliverable documents.

Several types of sources were used to research and collect support equipment identification, characteristics, and performance data. CSC and AL/HRG personnel visited several operating locations, interviewed users, collected data from equipment identification plates, reviewed applicable Technical Orders, and took photographs of selected items of SE. They also visited selected System Program Offices (SPO), obtained copies of selected Support Equipment Recommendation Data (SERD) from the F-16 and C-17 SPOs, obtained a list of approved Support Equipment Technical Data and a draft Support Equipment Mobility List from the F-22 SPO, reviewed the 1993 Northrop Study on Composite Wing Future Requirements, researched available Custody Authorization/ Custodian Receipt Lists, Tables of Allowances, AGE Master Plans, LOGPLAN Shop Material Lists, and the Federal Logistics Information Management System Database. A complete list of sources is included as a sub-table in the COLOR Database and in section 4.0 of the initial Support Equipment Database Report, and was updated in subsequent documents.

CSC data collection efforts for the SE database focused on SE items that would be deployed with the aircraft wing or squadron. Furthermore, the greatest atttention was given to those SE pieces that had the most significant impact on the deployment footprint. These items are usually included in a Unit Type Code equipment listing or "mobility list" required to support selected operational deployment plans. SE items that support the aircraft flight preparation and recovery and flightline organizational maintenance were the highest priority. These included start carts, ground power carts, air conditioners, air compressors, nitrogen and oxygen system

servicing carts, hydraulic test stands, hydraulic fluid and oil servicing carts, auxiliary lighting carts, cabin pressure leakage testers, aircraft towbars, and maintenance access platforms. These SE items are sometimes called rolling stock (they have wheels for transportability/mobility) or Aerospace Ground Equipment.

Product

CSC's first published deliverable was a listing of the COLOR Support Equipment Database dated 24 June 1994. All equipment listed in the database were grouped by various equipment types based on the functional application of the equipment. The equipment types researched were:

Air Bag Blower	Air Compressor	Air Conditioner
Aircraft Start Cart	Auxiliary Lighting	Crane
Deicer	Cabin Leakage Tester	Freon Recovery Unit
Ground Power	Hydraulic Jack Manifold	Hydraulic Servicing Cart
Hydraulic Test Stand	Lift Truck	Maintenance Stand
MASS	Nitrogen Servicing	Oil Servicing Cart
Oxygen Servicing	Power Cart Load Bank	Servicing Cart
Towbar	Trailer	

A page of information for every piece of equipment was included in the database for each equipment type. For example, within the air compressor equipment type there is information on the MC-1A, MC-2A, MC-7, MC-11 compressors, etc. The following information was collected for each piece of equipment: official designator, official nomenclature, common name, model number, National Stock Number (NSN), Master NSN, Generic NSN, applicable Technical Order number, manufacturer, dimensional data, weight, fuel or power source, cost, outputs, and purpose. There was also a remarks field for each piece of equipment to document comments of specific interest.

After the official delivery in June, CSC continued to collect SE data and populate the COLOR SE Database through November 1994. The updated version of the COLOR SE Database, dated 29 November 1994, was delivered to AL/HRG and imported onto their server. The database was shown to be accessible from local workstations and performed as required.

ACQUISITION MODEL

Background

By the Fall of 1994, the majority of the policy documents regarding Air Force acquisitions had recently been revised. These revisions reflected the changes associated with the consolidation of Air Force Systems Command and Air Force Logistics Command (AFLC) into a single Air Force Materiel Command. Additionally, there was a change in the publication philosophy resulting from the institutionalization of Total Quality Management principles and the near constant effort to improve the acquisition process. The acquisition process has a long history of change and seems to be under constant scrutiny by various political figures. The process is frequently criticized for inefficiency and accused of containing too much bureaucracy and red tape. The second deliverable, an Acquisition Model, documented the Air Force's changing organizations, policies, procedures, and practices used to acquire Air Force weapon systems. The report concentrated on the acquisition of SE and AGE.

Approach

CSC Professional Services Group consulted a significant number of Department of Defense publications during its research for the Acquisition Model. Those documents which yielded information included in the Acquisition Model are listed in Section 6.0 of the delivered document. CSC also conducted multiple interviews with Air Force operational and staff-level personnel during their research for the Acquisition Model.

Product

The Acquisition Model document begins with an overview of the military acquisition system. It then discusses the implementation of the relatively new Air Force acquisition concepts of Integrated Weapon System Management and Integrated Product Development. The Air Force acquisition system is structured to satisfy validated requirements which arise from various operations and maintenance situations. The Acquisition Model document discusses new support requirements generated by the introduction of a new weapon system into the inventory; requirements to replenish existing equipment with additional quantities of the same functionality and design; and the replacement of existing equipment with alternative designs.

In order for the acquisition system to satisfy the identified requirements, an appropriate source of program funding is required. The Acquisition Model provides a broad overview of the complex budget process associated with the acquisition of equipment. The acquisition processes employed to satisfy the new, replenishment, and replacement requirements are also presented in the document, as well information on several acquisition strategies that were devised to improve the acquisition process.

Several new and different approaches have been attempted to improve various parts of the SE acquisition process. "SE as a Capability" and "System Support/Early Depot Activation (SS/EDA)" are two approaches to improving the Logistics Support Analysis, SE identification, and SERD preparation processes. These programs provide incentives for the weapon system contractors to initiate the SE identification process earlier in the weapon system life cycle. Some

degree of success has been achieved on the C-17 Cargo Aircraft Program, B-2 Bomber Program, and other programs using the SE as a capability concept. The SS/EDA concept was described in a draft document prepared in part by HQ AFLC in 1989. SE Master Planning is an attempt by the functional area item manager specialist, equipment specialist, and users to improve the replacement process by analyzing current capabilities, consider long-term requirements, and establish plans to provide a satisfactory future support posture. Master Plans have been prepared for 20 SE functional areas. The plans represent an intelligent approach to defining future SE replenishment or replacement requirements and thus initiate the budgeting, funding, and contract business strategy planning in a more timely manner than reacting to shortages as they occur.

The Support Equipment Acquisition Model has many processes to address the many types of equipment. These processes will continue to be altered as political pressures continue to reduce money and personnel resources. Since the CSC Acquisition Model document was prepared, emphasis on the Joint Logistics System Center's efforts to establish one single information system for all DoD agencies has diminished, and a lack of funding has resulted in cancellation of the Joint Services Material Management Standard System Development Project. Those involved with defining, developing, and funding new programs must strive to maintain current knowledge of the Air Force and DoD acquisition processes as well as the programming, planning, and budgeting system processes.

PAYOFF ASSESSMENT ANALYSIS

Background

One objective of the COLOR program was to determine the nature of changing logistics requirements and problems created by recent mission and organizational changes in USAF operational wings. The increased focus on contingency operations requirements, the use of objective wings, and the lengthening of system life cycles had vastly altered the logistics requirements levied on existing systems and their related support systems. The purpose of the Payoff Assessment Analysis (PAA) effort was to review SE acquisition and operational problems and to identify areas where the Armstrong Laboratory and Air Force could best concentrate their research effort.

Approach

In order to better understand activities associated with deployment and deployment planning, CSC and AL/HRG personnel visited several operating locations, including HQ Air Combat Command and the 1st Fighter Wing, Langley AFB, Virginia; the 366th Composite Wing, Mountain Home AFB, Idaho; and the 178th Fighter Squadron, Springfield Air National Guard, Springfield, Ohio. To better understand the AGE items that contribute the most toward the deployment footprint, CSC researched and analyzed Unit Type Code (UTC) equipment listings from Langley, Mountain Home, Pope, Holloman, and Ellsworth Air Force Bases.

Product

The PAA document begins with a background discussion on mobility and deployment planning. This information was based on discussions with the mobility experts at the operational bases listed above. The document also defines reliability and maintainability (R&M) terms and discusses their importance. Additionally, R&M data elements that affect supportability and deployability are addressed. Background was provided on AGE proliferation, old technology designs, and special management attention to AGE problems, along with a partial list of current procurement actions to replace existing AGE.

Using UTC data, a matrix of AGE items was created, listing the associated weight and volume for each item. Similar items that perform essentially the same function were combined (e.g., B-1, B-2, B-4 and C-5 maintenance stands were combined under maintenance stands) to gain a better understanding of the type of AGE functions and equipment required. A list was created of the highest contributors by weight or volume for the ten UTCs (nine aircraft and one munitions) analyzed. A series of 22 tables were presented in the document, listing the top AGE items that contribute to the deployment footprint for the various wings analyzed.

Since the number of aircraft assigned to different wings varied, the average contribution toward the UTC total weight was calculated in terms of weight per aircraft. Tables provide the resulting weight contribution as pounds of AGE type per aircraft, the combined totals, and the percentage of total average weight per aircraft. Care should be exercised when using this average data since these tables are valid only for the specific UTCs and combinations of UTCs analyzed

for this effort. However, the tables provide an indication of the relative contribution for selected aircraft combinations.

The analysis showed that pallets are the largest contributor to the deployment footprint by both weight and cube. The AGE items then follow in some relative order of significance that differs depending on weight or cube. This list ranks the AGE items that need further investigation by reducing either the quantity or weight and volume required to support deployments.

Recommendations for areas that should be considered during the design of new AGE were included. Air transportability certification, aircraft load limits, hazardous materials special handling requirements, the Clean Air Act of 1990, Environmental Protection Agency noise and emissions pollution requirements, investigation of other services and NATO equipment, and limitations of failure data reporting for SE were also addressed.

The PAA document is useful for gaining an understanding of the mobility and deployment planning procedures; learning reliability and maintainability terms and their importance to deployment; and determining types of SE or AGE that contribute to deployment footprint for the selected operational wings. Most of the data in the PAA report is still valid, especially the considerations for design of new equipment. The UTC data should be valid for a relative comparison of the selected AGE items' contribution to the overall deployment footprint. The UTC for a specific operational squadron or wing is constantly undergoing review and revision. Care should be exercised to use current UTC information when addressing specific wing requirements.

AIRCRAFT PERFORMANCE DATABASE

Background

An August 1993 Northrop Study on Composite Wing Future Requirements detailed the concern of USAF management regarding the proliferation of SE Types and the quantities of SE units needed to support a deploying unit. One problem was the age of some of the equipment and the outdated designs used to build newer equipment. Poor reliability, maintainability, and supportability were a result of the AGE designs from the 1950s and 1960s. A larger problem stemmed from the newest USAF doctrine of global engagement, combined with the fact that the number of overseas operational units has been drastically reduced. This situation has put deployability concerns in the forefront, with AGE as a major deployability issue. Current studies have shown that 20-30% of the deployment footprint of a USAF operational squadron is created by AGE and its associated spares, personnel, tools, technical orders, fuel, and related items. The equipment is bulky, heavy, complex, and composed of parts lacking commonality. In many cases, different SE designs provide the same support functions resulting in additional spare and repair parts being maintained, expanded technician training, and increased technical data. The majority of SE items are designed to perform a single aircraft servicing or repair function.

As a possible solution to these problems, AL/HRG's Modular Aircraft Support System (MASS) program will design, build, and test new proof-of-concept aircraft ground power machines that could possibly supply electricity, cooling air, nitrogen, hydraulics, and related utilities in modular carts. During this process, greater attention to reliability and maintainability will reduce life-cycle costs and make MASS an affordable innovation for flightline use. A first step for this program was to determine actual aircraft servicing or maintenance task performance requirements rather than the capability of the SE or AGE end items. CSC's task was to determine the feasibility of researching and documenting the F-16 aircraft actual performance requirements. This required an update of the COLOR database by adding an Aircraft Performance Requirements Table to store and retrieve the resulting aircraft performance data collected.

Approach

Several types of sources were used to research and collect F-16 aircraft ground maintenance and servicing performance requirements. CSC collected and analyzed the associated SERD documents prepared by the F-16 weapon system development contractor and approved by the Air Force System Program Office. These SERD documents included a definition of the requirement and a recommended equipment solution.

Selected F-16 Aircraft System Specifications were reviewed to determine the detail included in such documents. The Ground Power Generator System Specification, the Ground Power Generator Cart (A/M32A-85), and the Air Conditioning Cart (A/M32C-19) Prime Item Development Specifications were also collected and reviewed.

CSC researched applicable F-16 Technical Orders (TOs) for the different types of servicing and maintenance tasks, as well as when each task is performed. They recorded the

AGE items specified by the TOs and reviewed and analyzed the maintenance procedures to identify any specific definition for electrical power, hydraulic, pneumatic, conditioned air, or lighting requirements. Tasks requiring any of these parameters were incorporated into the COLOR Database Aircraft Performance Requirements Module. Maintenance and servicing tasks associated with aircraft preflight inspections, walkaround inspections, post-flight inspections, 200-, 400-, and 800-hour phased inspections, 30-, 60-, 90-, 120-, and 180-calendar day inspections, and special inspections and operational performance checks were selected and analyzed.

To address the most frequently performed unscheduled maintenance tasks, data was obtained from the F-16 system support manager at Ogden Air Logistics Center. Using the Reliability and Maintainability Information System, the top 100 Low Mean Time Between Failure subsystems were identified for the F-16 C/D, Block 50 series aircraft using flying hour data collected over a two-year period. Due to availability of resources, CSC chose to include the top 50 failure-generated actions in the database. TOs were researched for these top 50 maintenance actions to determine specific performance parameters for electrical power, hydraulic, pneumatic, conditioned air, or lighting requirements.

CSC obtained data from the F-16C, Block 50 Electrical Loads Analysis document titled "Aircraft F-16C Block 50 Electrical Load and Power Capacity Analysis," Document Number 16PR9018, Revision A, dated 15 November 1992. With the assistance of the Electrical Subsystem Engineer from the F-16 SPO and the Electrical Loads Analysis document, electrical power usage data were calculated for many of the selected maintenance and servicing tasks.

Scheduled maintenance tasks were derived from TO 1F-16CJ-6, Scheduled Inspection and Maintenance Requirements. Together with the top 50-failure generated maintenance actions (unscheduled maintenance), these tasks were sorted by Work Unit Code (WUC). Each WUC was researched to identify a specific maintenance task and its subsequent operational functional check. The 1F-16JG Series Job Guides were used to identify the particular support equipment requirements and the parameters of their operation for each task.

To obtain the electrical power consumption for each task or operational functional check, a more in-depth analysis of the aircraft circuitry had to be performed. Fault identification wiring diagrams or fault trees were identified in the Job Guides for each functional check. Using these diagrams, the circuitry can be traced back to the applicable aircraft circuit breaker. Once the loads were established for each circuit breaker and the particular circuit breakers identified to perform each task, they were combined at the appropriate terminal board junctions to arrive at a final calculation for total power consumption in kilo-volt amperes (kVA) for each maintenance task. The calculated electrical power consumption values for each task were entered into the COLOR Database Aircraft Performance Requirements Module tables.

Air conditioning requirements for the selected maintenance and servicing tasks were difficult to identify. Many factors influence air conditioning cooling parameters: ambient temperature, cooling air temperature, cooling air flow, pressure, equipment heat dissipation aids (heat sinks), forced-air cooling, free convection, volume of space, heat build-up, standard day,

and others. In order to calculate a cooling parameter for comparison, a standard day with air conditioner output cooling air temperature of 50°F was assumed. The calculated electrical power consumption for continuous operation, along with the F-16C Prime Item Development (PID) specification equipment cooling requirements, were used to calculate the expected heat dissipation and thus the air flow required to provide adequate equipment cooling. The PID specification cooling air flow was defined at 0°F, 35°F, and 80°F. An extrapolation between the 35°F (2.25 ppm) and 80°F (3.95 ppm) was made to compute an equivalent cooling air flow of 2.44 ppm per kilowatt of heat dissipation with a cooling air temperature of 50°F. This value was used to calculate minimum cooling air flow requirements for each maintenance task. The resulting cooling air parameter should not be considered to represent an absolute cooling requirement, but can be used to identify the maintenance tasks with higher cooling requirements.

Product

Volume III of the Updated COLOR Database report dated 31 May 1995 contains the Aircraft Performance Requirements Database Record Listing. This listing contains 140 records of F-16 maintenance and servicing tasks. For each task, the amount of electrical power required from the ground power generator is listed, as well as the requirements for cooling air, pneumatics, hydraulics, and lighting. A remarks section highlights any special requirements or additional items of interest. The report page format was created using the Microsoft FoxPro Report Writer and the records are ordered alphabetically by maintenance task. The report format can be altered and the record order changed for individual user preference using the Microsoft FoxPro Report Writer.

After collecting the F-16 data, AL/HRG felt the usability of the Aircraft Performance Requirements Module could be enhanced by collecting, analyzing, and documenting flightline maintenance and servicing requirements for additional aircraft. Due to the time consuming nature of such analysis, AL/HRG contracted with Battelle Memorial Institute to aid CSC in their analysis. Additionally, the teams concentrated mainly on electrical power and air conditioning requirements for the ground maintenance and servicing tasks. The CSC team analyzed the KC-135, C-17, C-141, F-117, and F-18 aircraft, while Battelle was responsible for the F-15, F-22, C-130, A-10, and B-52. As additional information was collected, CSC updated the database as necessary. The usability of the Aircraft Performance Requirements Module could be enhanced by adding data elements associated with additional aircraft flightline support requirements for these aircraft. Additional elements might include hydraulics, pneumatics, lighting, and heating requirements.

AIRCRAFT ELECTRICAL MEASUREMENTS

Background

In an attempt to improve the accuracy of the data contained in the Aircraft Performance Requirements Module, AL/HRG chose to conduct field tests to measure the actual performance of selected maintenance or servicing tasks. Initially, the laboratory planned to measure electrical power consumption and air conditioning requirements on various aircraft. After discussing techniques for measuring conditioned air with several companies familiar with this task, AL/HRG felt the costs and risks associated with these measurements outweighed the potential benefit. Therefore, this part of the effort was canceled and CSC was tasked to conduct aircraft electrical measurements only. Battelle Memorial Institute assisted with the measurement of the aircraft they had researched in the previous tasking.

Approach

In order to determine the actual electrical power requirements of various aircraft during ground maintenance tasks, a method of selecting tasks and measuring the electrical power was developed. Before any measurements could be taken, it was necessary to determine which maintenance task required the most electrical power. Identifying these "high driver" systems for each of the assigned aircraft was difficult and time consuming. The maintenance tasks or "operational checkouts" were selected from the initial electrical load analysis and by popular opinion of maintenance specialists. Using the same technique as the F-16 task selection, the electrical requirements for the high driver systems were estimated by using the schematics of the system and cross referencing them to the load analysis for values of VA or amps flowing through the circuit breakers. The values were then totaled to arrive at an estimate of kVA for each maintenance task. Operational units were then requested to perform whichever task CSC determined had the highest kVA. Some of the high driver systems (landing gear retraction, radar checks, and other transmitting systems) were difficult to schedule for measurements due to their infrequent occurrence.

Once the maintenance task requiring the most electrical current was identified, the actual methodology to measure the current still needed to be considered. Initially, measurements were taken using three clamp-on type ammeters. The ammeters were clamped onto each phase of the aircraft power cable to measure the current flow during the selected functional check. Since this process required a minimum of three people to constantly monitor the separate ammeters, inaccuracies resulted because the display was missed or misread. Therefore, the technicians attempted to monitor the process with a video camera. However, it was nearly impossible to position all three ammeters in a way that allowed clear capture of the displays with the camera. At this point, AL/HRG leased the DRANETZ Power Platform 4300 from General Electric Capitol Company. It was the only measuring device that could measure three-phase power and store that data into memory.

The battery operated DRANETZ meter was capable of recording amps and volts in true Root Mean Square (RMS), as well as watts, Volt-Ampere Reactive, power factor, and harmonic distortion. An Air Force ground power junction box was used as an interface between the

ground power generator and the aircraft being measured. Amp probes from the junction box fed the 4300 Power Platform. After the meter was turned on and programmed to record at specific voltages, the maintenance technicians performed their functional checks as usual. For statistical accuracy, CSC tried to perform at least two measurements of a particular task on two different tail numbers.

Product

The measurement phase of the COLOR project was accomplished during an eleven month period ending in November 1996. The Aircraft Electrical Measurements Report was delivered to AL/HRG on 28 February 1997. The report contains the purpose for conducting aircraft electrical measurements, equipment used, methods of testing, aircraft tested, results of the measurements, and lessons learned. Step-by-step procedures for setting up and programming the DRANETZ power platform are included, should anyone wish to duplicate this effort with additional aircraft or different maintenance tasks. As a result of this study, fifty-two separate electrical power measurements on ten different aircraft models were completed.

CONCLUSIONS

This report has provided a brief overview of the six separate tasks accomplished by Computer Sciences Corporation for the Armstrong Laboratory, Logistics Research Division. Anyone interested in obtaining an original copy of the reports mentioned in this summary should contact AL/HRG.

The results obtained from the various tasks performed by CSC over the past three years will benefit not only Armstrong Laboratory, but the entire Air Force. Their efforts have provided a single source for data required in the Modular Aircraft Support System project and will contribute to any future support equipment R&D programs. This data should also support key decision makers on the Aerospace Ground Support Equipment Working Group by easily providing data that was either previously unavailable or spread among numerous data repositories.

Finally, the program helped spawn an additional effort titled Support Equipment Evaluation/Improvement Techniques (SEE/IT). This program updates COLOR data and the database; combines it with technologies from government, industry, and academia sources; and determines potential research efforts beyond MASS.

BIBLIOGRAPHY

Northrop Advanced Technology and Design Center. (1993, August). Composite Wing Future Requirements Study. Pico Rivera, CA.

Boyle, E., Tracy, M., & Smoot, D. (1995). Rethinking Support Equipment. Air Force Journal of Logistics, 19 (4), 28-33.

Tracy, M., Pavek, D., & Schroeder, J. (1997) A Support Equipment Improvement Opportunity. Paper to be presented at the National Aerospace & Electronics Conference, Dayton, OH.

Computer Sciences Corporation. (1994, June). COLOR Support Equipment Database. Fairborn, OH.

Computer Sciences Corporation. (1994, October). COLOR Acquisition Model. Fairborn, OH.

Computer Sciences Corporation. (1994, December). Payoff Assessment Analysis. Fairborn, OH.

Computer Sciences Corporation. (1995, May). Updated COLOR Database. Vol. 1-3. Fairborn, OH.

Computer Sciences Corporation. (1997, February). Aircraft Electrical Measurements. Fairborn, OH.